USING CURRENT COMMAND AND CONTROL SYSTEMS, IS IT POSSIBLE TO USE SENSORS TO PROVIDE A NEAR-PERFECT LOGISTICS COMBAT POWER ESTIMATE TO ARMY BRIGADE COMMANDERS?

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Meeting the challenges inherent in full-spectrum operations has presented Army commanders with missions that are becoming more and more complex. As a result, the need for timely and accurate information is becoming even more critical to enable commanders to make the best possible decisions to effectively plan and conduct these operations. One of the most critically important information requirements needed by commanders is the visibility of his combat power. A commander must know the current and projected combat ready personnel, equipment, and supplies available to plan and conduct military operations. The two primary command and control (C2) automated systems at the tactical level to assist in performing this requirement are the combat service support control system (CSSCS) and the Force XXI Battle Command Brigade and Below (FBCB2). Though these C2 systems have significant capabilities, they have significant shortfalls in providing timely and accurate combat power visibility. The main purpose of this thesis is to determine if there is a better method to populate and update the current C2 systems through the use of sensors to provide a near-perfect combat power estimate.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

USING CURRENT COMMAND AND CONTROL SYSTEMS, IS IT POSSIBLE TO USE SENSORS TO PROVIDE A NEAR-PERFECT LOGISTICS COMBAT POWER ESTIMATE TO ARMY BRIGADE COMMANDERS by MAJ D. Alan Morgan, 60 pages.

Meeting the challenges inherent in full-spectrum operations has presented Army commanders with missions that are becoming more and more complex. As a result, the need for timely and accurate information is becoming even more critical to enable commanders to make the best possible decisions to effectively plan and conduct these operations. One of the most critically important information requirements needed by commanders is the visibility of his combat power. A commander must know the current and projected combat ready personnel, equipment, and supplies available to plan and conduct military operations. The two primary command and control (C2) automated systems at the tactical level to assist in performing this requirement are the combat service support control system (CSSCS) and the Force XXI Battle Command Brigade and Below (FBCB2). Though these C2 systems have significant capabilities, they have significant shortfalls in providing timely and accurate combat power visibility. The main purpose of this thesis is to determine if there is a better method to populate and update the current C2 systems through the use of sensors to provide a near-perfect combat power estimate.

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ACRONYMS

ABCS	Army Battle Command System
ALCON	Administrative/Logistics Operations Center
BOIP	Basis of Issue Plan
C2	Command and Control
CASCOM	Combined Arms Support Command
CEP	Concept Experimentation Program
CPD	Combat Power Display
CSS	Combat service support
CSSCS	Combat Service Support Control System
FAS	Feasibility, Accessibility, and Suitability
FBCB2	Force XXI Battle Command Brigade and Below
FBCB2	Force XXI Battle Command Brigade and Below
FM	Field Manual
ISD	Information Systems Directorate
LOGSITREP	Logistics Situational Report
MOOTW	military operations other than war
MTS	Major theater of war
PERSITREP	Personnel Situation Report
SAAS-MOD	Standard Army Ammunition System- Modernized
SAMS-2	Standard Army Maintenance Systems-2
SARSS-O	Standard Army Retail Supply System Level-1 (Objective)
SIDPERS	Standard Installation and Division Personnel System
SPBS-R	Standard Property Book System-Redesigned

STAMIS	Standard Army Management Information Systems
ULLS-S4	Unit Level Logistics System-S4

ILLUSTRATIONS

CHAPTER 1

INTRODUCTION

> The dangers of the modern security environment and the implications to our way of life that responding to those threats entail has focused our nation, as well as the Army. (PM-ATCCS, Battle Command in Future Conflict, 2002, 1-1)

The 11September attacks on the World Trade Center and Pentagon serve as sobering examples that the strategic environment continues to remain dangerous and unpredictable. Additionally, the new "War on Terrorism" and North Korea's refusal to abide by existing nuclear proliferation agreements present the US with the realities of the dangers that threaten the security of the American people, allies, and US interests abroad. Regardless of the danger and unpredictability, the Army is expected to meet its nonnegotiable contract with the American people to "fight and win our nation's wars" (Field Manual (FM) 3-0 2001, 1-1). To that effort, the Army is expected to have the ability to conduct operations that span the "full spectrum" of military operations ranging from military operations other than war (MOOTW) to full-scale combat operations in a major theater of war.

Meeting the challenges inherent in "full-spectrum" operations has presented Army commanders with missions that without question are becoming more and more complex. As a result, the need for timely and accurate information is becoming even more critical to enable commanders and staff to effectively plan and conduct operations at the tactical level. At the brigade level, one of the most critically important information requirements needed by a commander is the visibility of his combat power, the focus of this thesis. A commander must know the current and projected combat ready personnel, equipment, and supplies available to effectively plan and conduct military operations.

Purpose

In efforts to provide a commander with accurate visibility of his combat power to plan and conduct military operations, the purpose of the thesis is determine if sensors placed on combat and combat service support vehicles and equipment can populate and update current command and control (C2) systems to provide a near-perfect combat power estimate.

A brigade commander relies on his staff located in the brigade's Administrative/Logistics Operations Center (ALOC) to compile manual and automated reports to create the combat power estimate. Located at the ALOC are the brigade S4 and the FSB support operations officer who serve as the primary staff officers responsible to develop the combat power estimate. There are two C2 automated systems located in the brigade ALOC that are designed to provide C2 capabilities, visibility of a brigade's CSS requirements, and available combat power. These systems are the Combat Service Support Control System (CSSCS) and the Force XXI Battle Command Brigade and Below (FBCB2). CSSCS provides C2 capabilities through collecting, processing, and displaying combat service support information and the FBCB2 system provides battle command and situational awareness information from brigade level down to the soldier/platform level. Though these systems have significant capabilities, they have major shortfalls in providing timely and accurate combat power visibility. The main issue is that both systems are highly dependent upon manual data entry to maintain their databases. As a result, data residing in these systems are not always accurate due to human error. Additionally, data that resides in these systems are not always current because updates submitted by soldiers are late or in the worst case, never actually get input.

Research Questions

The primary research question of this thesis is: Using current C2 systems, is it possible to use sensors to provide a near-perfect logistics combat power estimate to Army brigade

commanders? Field Manual (FM) 3-0 (100-5) states that: "Combat Power is the ability to fight. It is the total means of destructive or disruptive force or both, that a military unit or formation can apply against the opponent at a given time. Future Combat Power is the projection of combat power given a battle rhythm and phase of an operation, overtime by unit" (CAC 2002, 6).

The next issue addressed in this thesis is that the information in the current C2 systems does not adequately consolidate combat power information in a user-friendly format. To solve this issue in CSSCS, the Combined Arms Center at Fort Leavenworth, Kansas, developed the Combat Power Display (CPD). The CPD was designed to consolidate a brigade's combat power estimate in "user-friendly views." The second question examined in this thesis is if implemented in CSSCS, can the CPD provide the required logistics combat power visibility to Army brigade commanders to plan and conduct missions at the brigade level?

Due to the problems discussed, commanders and staff have reduced confidence in CSSCS, and in many cases they choose not use the system. If CSSCS is not utilized, the ALOC is confronted with a very time-consuming process to compute a brigade's combat power and information used is normally between six to twenty-four hours old (CASCOM 2002b, 3).CSSCS is the only automated system designed and fielded to perform this function in the brigade ALOC. Therefore, it is imperative C2 and decision-making functionality is increased in CSSCS to restore confidence in the system. To that effort, the third and final question addressed in this thesis is, how can the ALOC use the proposed solution to improve C2 anddecision making?

Background

"The Combat Service Support Control System (CSSCS) is the CSS component of the Army Battle Command System (ABCS). ABCS comprises seven separate systems to support key C2 functions of maneuver, fire support, air defense, intelligence, air support, battle command and combat service support. The ABCS integrates the command and control systems found at each

echelon-from ground-force component commander at the theater or joint task force level to the individual soldier or weapons platform" (PM-ATCCS 2001a, 2).

CSSCS was designed to provide a concise picture of unit requirements and support capabilities by collecting, processing, and displaying information on key items of supply, services, and personnel that the commanders deem crucial to the success of an operation. Through interfaces to the other ABCS systems, these nodes provide the brigade ALOC with the battlefield common relevant operating picture (CASCOM 2002b, 3). Data that populates CSSCS is obtained from data feeds from the family of the Standard Army Management Information Systems (STAMIS). An example of STAMIS use, within the brigade, is ordering and stocking supplies, initiating maintenance actions, and requests for medical and personnel support operations. As discussed earlier, STAMIS are heavily dependent upon manual entry; therefore, data that is fed into CSSCS is sometimes not accurate or up to date. Additionally, CSSCS requires some specific CSS data that is only input manually. Fuel input for unit and direct support status and ammunition status are examples of purely manual processes due to the fact that there are no STAMIS systems fielded to feed CSSCS. Additionally, CSSCS requires manual input for CSS supply locations. The specific challenge for this research is to determine if sensors are available that could eliminate STAMIS and CSSCS dependency on these manual data feeds. Additionally, the research needs to determine if sensors are available to populate the CPD in CSSCS with the required source data for the CSS functions that have no STAMIS. For that to be possible all sensor-based feeds from combat and CSS vehicles and equipment must be adequate in scale and scope to provide the necessary data to populate the CPD and improve the C2 and decision-making capability of the system.

CSSCS interfaces with the following STAMIS: Standard Property Book System-Redesigned (SPBS-R), Standard Army Maintenance Systems-2 (SAMS-2), Standard Installation and Division Personnel System (SIDPERS), Standard Army Retail Supply System Level-1

(Objective) SARSS-O, Standard Army Ammunition System- Modernized (SAAS-MOD), and the Unit Level Logistics System-S4 (ULLS-S4).

The briefing “Commander’s Combat Power Display” for CSSCS states that the current form of CSSCS does not provide the maneuver commander the information needed to build, track, and sustain combat power. One of the main problems with CSSCS is that it does not present a brigade’s combat power estimate in a consolidated format. As a result, users must access multiple screens and manually extract data to view a brigade’s combat power estimate. Additionally, CSSCS requires that information be extracted in the form of a status report and sent to other ATCC systems with no “drill down” capability (CAC 2002, 3). Drill down capability refers to the ability to access more detailed information about a topic.

As stated, the commander’s CPD that was developed by Lieutenant Colonel John P. Curran of the Combined Arms Center serves as a basis for this research. The scope of this research is limited to the CSS functions addressed in the CPD. These areas are fuel, ammunition, maintenance, and medical support. Of all the CSS functions, these areas have the most significant impact on building, maintaining and sustaining combat power.

The data provided by sensors to populate the CPD must be sufficient in scale, scope, and reliability. Information that has changed or is no longer relevant for planning, C2, and decision making provide little to no value-added assistance. The goal of this research is to determine if a solution exists to reduce or in the best case, eliminate the amount of manual entries required to populate the CPD.

Another ABCS C2 system that is critical in this research is the Force XXI Battle Command Brigade and Below (FBCB2). “FBCB2 is a digitized Battle Command Information System that provides on-the-move, real-time, and near-real-time battle command information to tactical combat, combat support, and combat service support leaders and soldiers” (CASCOM 2002h, 1). FBCB2 is an important component of the Army Battle Command System (ABCS) that

was designed to integrate with the other components of ABCS family of systems at the brigade and below level. FBCB2 provides situational awareness down to the soldier/platform level across all of the current battlefield functional areas (BFAs) and echelons. There are two reports in FBCB2 that provide information to CSSCS that is used to create a logistics estimate. These reports are called the Logistics Situational Report (LOGSITREP) and the Personnel Situation Report (PERSITREP). The LOGSITREP provides platform and unit-level logistics status and the PERSITREP provides a unit’s personnel status report. “Both reports originate at the Combat or CSS vehicle level where FBCB2 is employed. These reports are rolled-up within FBCB2, maintaining individual unit integrity; and forwarded via the Tactical Internet (TI) to the first echelon where CSSCS is deployed” (CASCOM 2002h, 2).

The standard in most Brigade Standing Operation Procedures (SOPs) is that normally the LOGSITREP and the PERSITREP are electronically sent twice a day. Once the systems crew fills out the reports, they are forwarded to the company first sergeant. The first sergeant then consolidates the unit report and sends it electronically to the battalion S4. The battalion S4 in turn consolidates the battalion reports and sends the reports electronically to the brigade S4 at the ALOC. Even though this process resides on an automated C2 system at the platform level, the report’s process is fully dependent upon manual input to complete and forward. That means that a soldier must stop what he or she is doing to fill out the reports and electronically send them up the submission chain of command, where they are reviewed at each level, described, and then forwarded accordingly. Unfortunately, competing requirements during operations often prevent soldiers from timely and accurate LOGSITREP and the PERSITREP submissions.

Based on the FBCB2 Basis of Issue Plan (BOIP), most CSS vehicles are not targeted to get FBCB2 equipment. Even CSS vehicles with a FBCB2 system do not have the capability via the FBCB2 software to report the vehicle’s CSS retail logistic assets. As an example, a 2,500-

gallon fuel tanker with FBCB2 does not transmit the amount of fuel remaining in the vehicle for retail distribution.

To increase the C2 and decision-making capability of an ALOC, the ALOC needs an improved common operating picture that presents accurate visibility of current and projected combat ready personnel, equipment, and supplies. This information is essential to effectively plan and conduct operations at the brigade level. FBCB2 and CSSCS do not adequately provide this capability. Overlays depicting the location of CSS supply locations are manually input. Since they are manually input, the icons remain static until changed. As stated earlier, CSS retail assets on CSS vehicles are not reported via FBCB2. This results in limited visibility at the ALOC to plan and conduct CSS missions to build, maintain, and sustain combat power for the brigade. A potential solution researched is the use of the Movement Tracking System (MTS). "MTS is a two-way non-line of sight satellite worldwide communications system that provides near-real time transportation asset location, movement data, and situational awareness" (CASCOM 2002i, 2). MTS has been selected by the Combined Arms Support Command (CASCOM) as the system of information management at the CSS platform/equipment level. If successful, the use of MTS, FBCB2, and sensors on combat and combat service support vehicles and equipment can auto-populate the CPD in CSSCS with organic and retail fuel, ammunition, maintenance, and personnel status.

In efforts to use proven methodology and technology, this research is based on the Anticipatory Logistics, Concept Experimentation Program (CEP). The CEP was an experiment in Anticipatory Logistics Functionality for the Global Combat Support System - Army using FBCB2 and MTS with links to CSSCS to remotely sense and trigger logistics actions for Class III bulk, Class V, and maintenance condition status for combat and tactical vehicles. Additionally, the CEP details a method to improve the C2 and decision-making capability of CSSCS. The concept developed and tested during the CEP took source data obtained from sensors on combat

and CSS vehicles and forwarded the data via FBCB2 and MTS. A Class III retail bulk fuel supply point was also fitted with sensors and MTS. All data feeds from the vehicles and the supply point were sent to an ALOC C2 computer system designed to mimic CSSCS. The C2 system in the ALOC had "real-time" data feeds that populate a CSS overlay in the system. Due to the real-time feeds in the C2 system in the ALOC, the ALOC had real-time visibility of the class III bulk supply point and the combat and CSS vehicles. The CSS overlay in the mock CSSCS system depicted real-time vehicle movements and CSS status for fuel, ammunition, and maintenance status.

In summary, the anticipatory logistics CEP has great potential in identifying possible solutions to the research questions posed in this thesis. Without question, building, maintaining, and sustaining combat power through the full spectrum of military operations is becoming more and more complex. The need to provide commanders with accurate visibility of their combat power is critical to plan and conduct operations at the tactical level. To that effort, the CEP, as well as all articles, documents, and literature used to conduct this research, will be further discussed in the chapter 2, "Literature Review."

CHAPTER 2

LITERATURE REVIEW

> Nurture your minds with great thoughts. To believe in the heroic makes heroes. (1871, 2)
>
> Benjamin Disraeli

The purpose of this chapter is to detail the articles, documents, and literature used to conduct this research. As new technology has emerged, many solutions to the problems discussed in the previous chapter are being accomplished. By capitalizing on these emerging technologies, the goal of this research is to determine if it is possible to use sensors to provide a near-perfect logistics combat power estimate to Army brigade commanders while using the current C2 systems. Additionally, this research seeks to answer the two supporting questions posed in this thesis: Is the current CPD adequate to provide the required logistics combat power estimate to Army brigade commanders to effectively plan and conduct missions at the tactical level, and how can the ALOC use the proposed solution to improve C2 and decision making in the ALOC?

Extensive literature was identified in order to answer the research questions posed with emphasis on two major efforts of work. The first is the anticipatory logistics CEP. The work accomplished by this CEP has great potential to provide a baseline from which to derive a solution for the use of sensors to provide a near-perfect logistics combat power estimate to Army brigade commanders. As the Chief of Science and Technology for the Combat Service Support Battle Lab located in the Combined Arms Support Command (CASCOM) at Fort Lee, Virginia, the author served as the primary technology architect and integrator for the CEP. Significant literature reviews for this program were performed to develop the concept and the research effort for this thesis will use much of the work as possible.

An article this research uses to answer its questions was written by Colonel Thet-Shay Nyunt, who was the deputy director for the CASCOM Information Systems Directorate (ISD), as

a lieutenant colonel. During his tenure in CASCOM he wrote this article that was published is the *Army Logistician* titled, “GCSS-Army- Making the Revolution in Military Logistics Happen.” Additionally, he coauthored an article with Colonel Shimko, the director for the CASCOM ISD, which was also printed in the *Army Logistician* titled, “Anticipatory Logistics Experiment and Smarter Vehicles: Embedded Diagnostics Lead the Way.” Both articles have extensive information relating to sensor-based data feeds from combat and CSS vehicles and equipment.

The next major effort of work that has significant potential to answer the research questions posed is the commander’s CPD developed by Lieutenant Colonel John P. Curran of the Combined Arms Center at Fort Leavenworth, Kansas. The interview of Lieutenant Colonel Curran and the Combat Power Display briefing are two sources of information used in detail for the research of this thesis. This briefing was a result of the Combined Arms Center Commander requesting tactical commanders to specify what information they would like to build, track, and sustain combat power (CAC 2002, 4). This briefing has great potential for this effort because of the fact the information requirements have been identified and confirmed by tactical commanders.

Manuals, briefings and information papers will be used for all systems described in the previous chapters of this thesis, such as: CSSCS, FBCB2, MTS, and the STAMIS: SPBS-R, SAMS-2, SIDPERS, SARSS-O, SAAS-MOD and ULLS-S4, will be used for this research. Additionally, various monographs, from the Advanced Operational Art Studies Fellowship, Master of Military Art and Science theses, FMs, and student text from the U.S. Army Command and General Staff College that address many of the issues outlined in this thesis were identified.

Sufficient research material exists to populate the CPD in the areas of fuel, ammunition, and maintenance through the use of sensors. The use of sensors to populate the medical portion is limited, but sufficient data resides in CSSCS to populate the medical portion of the CPD. Additionally, sufficient research material exists to answer the question if the CPD is adequate to

provide the required logistics combat power estimate to Army Brigade commanders to effectively plan and conduct missions at the tactical level. Most of the work to answer this question was performed by the Combined Arms Center and the research is sufficient in scope and scale to answer this question. To answer the question of how the ALOC can use the proposed solution to improve C2 and decision making in the ALOC, the anticipatory logistics CEP research and the additional literature discussed in this chapter is sufficient to answer the question.

The civilian industry has accomplished significant work that will contribute to the research of this thesis. The first series of articles used detail various approaches and methods used by civilians for problem solving. *The Process Imperative* and the *Business Integration Journal* are two such publications used in this research. The intent is to use the best methodology for the analysis of the complex problems inherent in the use of sensors to populate the CPD in CSSCS. "Real-time information flow within organizations and across corporate boundaries requires integration at the process level, as opposed to merely linking the technologies" (Mega Corporation 2002, 6). The article details how to divide a process into manageable and measurable segments. Analyses of these segments will help the researcher to understand the detailed processes and to identify areas where improvements can be made to improve the overall process. The concepts detailed in these articles contributed significantly in the development of the method used to analyze the use of sensors to populate the CPD in CSSC. To that effort, the CPD segments that make up the report are Equipment and Maintenance, Fuel, Ammunition, and Personnel. These are the segments that require sensor-based data. The civilian sector has achieved significant successes in gaining situational awareness of customer vehicles through the use of existing technologies, including sensors. Enabled by this visibility, customers receive innovative services discussed below. The lessons learned and technologies utilized by these solutions clearly have applications and technical approaches that can be used in this research. To that effort, the

next series of articles used in this research detail the technology and capabilities available with the "OnStar" system.

"Using a sophisticated Global Positioning System, OnStar brings you safety, security and information via live personal service. And it's available 24 hours a day, 365 days a year --all at the touch of a button" (Smart Motorist, Inc. 2002, 1). OnStar utilizes telephone and satellite technologies to transmit status/information about a customer's vehicle. "OnStar starts with sophisticated Global Positioning System Satellite information to locate the vehicle, wireless communications to seamlessly link the vehicle to the OnStar Center, integration of the OnStar system to the wiring in the vehicle, and a professionally staffed center that's available 24 hours a day, seven days a week with access to sophisticated computer databases and mapping software" (Smart Motorist, Inc. 2002, 2). OnStar services include:

1. Emergency Services: one button access to an OnStar advisor. The advisor can locate the vehicle on a digital map and alerts the nearest emergency service.

2. Remote Diagnostics: If a warning light in the vehicle is activated, the vehicle can transmit any problem codes generated by the vehicle engine computer. The problem codes are generated from the onboard computer directly linked to sensors mounted on a customer's vehicle. If required, the OnStar advisor can set up immediate or near-term maintenance appointment to fix the problem.

3. Automated contact: if a vehicle's air bag is activated then a signal is sent to the OnStar center automatically. An OnStar advisor will attempt to communicate with the vehicle's occupants and if the advisor is unsuccessful, the advisor can determine the exact location of the vehicle and call for emergency assistance.

4. Stolen Vehicle Tracking: If a customer's vehicle is stolen, then the OnStar advisor can obtain the location of the vehicle and contact the nearest police department.

5. Remote Door Unlock: If a customer locks his or her keys in the vehicle, a customer can call a toll-free number and have an OnStar advisor can send a signal to the vehicle to unlock the door remotely.

As new technologies, such as OnStar, emerge many solutions to the problems addressed in this thesis are solved. The OnStar system serves as an example that it is technically possible to use sensors to gain unparalleled situational awareness. Many of the capabilities achieved through emerging technology are incredibly innovative as shown by the OnStar capabilities. It is through the use of similar technologies, that it is possible to achieve similar situational awareness for a logistics common operating picture. Enabled by a logistics common operating picture, a brigade commander could have visibility of his current and projected combat ready personnel, equipment, and supplies to plan and conduct military operations. In the next chapter, the research methodology and method of evaluation for this thesis are discussed in detail.

CHAPTER 3

RESEARCH METHODOLOGY

> To guarantee or improve the performance of a process, we must understand it. This includes the interaction between people, information, business rules and constraints, resources and technologies. (MEGA Corporation 2002, 14)

The purpose of this chapter is to address the methodology used to answer the primary question, using current C2 systems; is it possible to use sensors to provide a near-perfect logistics combat power estimate to Army brigade commanders, as well as the two supporting questions posed in this thesis. The method of evaluation used in this thesis to answer the research questions is a qualitative versus a quantitative method. The qualitative method chosen uses a combination of comparative analysis using deductive and inductive logic and the use of the Army's Feasibility, Accessibility, and Suitability (FAS) test.

The first supporting research question was to determine if the current CPD is adequate to provide the required logistics combat power estimate to Army Brigade commanders to effectively plan and conduct missions at the tactical level. To answer the question, the information resident on the CPD was compared to feedback provided by commanders at the tactical level to determine what logistics information is required to gain sufficient visibility of a brigade's combat power. Since the primary users of this report are commanders and staff at the brigade level, this approach was effective in determining the acceptability and suitability of the CPD.

The comparative analysis technique was used to determine if the ALOC could use the proposed solution to improve C2 and decision making. New or improved ALOC process actions that better build, maintain, and sustain brigade combat power though better C2 and decision making are the focus of this analysis. ALOC process improvements gained from the proposed solution would be compared from current to projected capabilities.

Improvements in C2 and decision making in the ALOC are somewhat subjective in nature because many opinions vary in regards to the best optimization solution. Due to this issue, the method of comparative analysis using deductive and inductive logic to reach conclusions is the best approach. “Deduction relies upon observations based on prior expectations or theories; in contrast, induction relies upon the evolution of theory from observations, requiring objective observations. The observer detects patterns in the observations to formulate a theory” (Jones and Olsen 1996). Both deductive and inductive logics will be used during my analysis detailed in chapter 4, “Analysis.”

In the article “Evaluating National Security Strategy and National Military Strategy,” Lieutenant Colonel Ted Davis, US Army (retired), defines feasibility as an assessment of the concept (ways) given the resources available (means). Bottom line, can the action be accomplished by the means available? Using feasibility as an evaluation criterion requires examining the underlying assumptions of the concept. For the purpose of evaluating and testing the thesis, the use of sensors and the methodology must be at “end-state” achievable.

Acceptability determines the cost effectiveness of a concept. The issue that is important for this criterion is that the gains outweigh the costs. “Basically, a concept is acceptable if the concept’s consequences are justified as demonstrated by the results of a cost-benefit analysis” (Simerly 2002). The key issue for this thesis concerning acceptability is does the level of increased ALOC C2 and decision making justify making the required changes in CSSCS? As stated earlier, CSSCS is many times not used due to the fact that the system is not “user friendly” and has limited C2 capabilities. The analysis of CSSCS system capability improvements as compared to the current capabilities of CSSCS is the approach used to determine the cost and benefits analysis.

The last component of the FAS test is Suitability. Suitability (Adequacy) examines the issue of accomplishing the desired effect. The solution is suitable/adequate if successful

achievement contributes to or accomplishes the desired effect (Simerly 2002,40). The Suitability/Adequacy issue for this thesis is centered on answering the thesis primary and secondary questions that sensors can or cannot be used to achieve the desired capabilities as outlined in this thesis.

The purpose of chapter 4 is to integrate the research materials and methodology discussed in this thesis and determine if using the current C2 systems, is it possible to use sensors to provide a near-perfect logistics combat power estimate to Army brigade commanders, is the current CPD adequate to provide the required logistics combat power estimate to Army brigade commanders to effectively plan and conduct missions at the tactical level and if the ALOC can use the proposed solution to improve C2 and decision making in the ALOC.

CHAPTER 4

ANALYSIS

As our case is new, so must we think and act anew. (1862)

Abraham Lincoln

The purpose of this chapter is to integrate the research materials and methodologies discussed in the previous chapters to provide a critical analysis of the primary and secondary research questions posed in this thesis. The primary research question analyzed is using current C2 systems, is it possible to use sensors to provide a near-perfect logistics combat power estimate to Army brigade commanders? A primary goal of this thesis is to provide a commander with visibility of his brigade's combat power to plan and conduct military operations. Additionally, this research seeks to answer the two supporting questions posed in this thesis: Is the current CPD adequate to provide the required logistics combat power estimate to Army brigade commanders to effectively plan and conduct missions at the tactical level and how can the ALOC use the proposed solution to improve C2 and decision making in the ALOC?

In efforts to provide a critical analysis of a potential method to provide a near-perfect logistics combat power estimate to a brigade commander, an assumption was made by the researcher that CPD functionality had been established in the CSSCS. "All required data for the Commanders Combat Power Displays currently reside with CSSCS" (CAC 2002, 17). Unfortunately, the data in CSSCS is not always accurate due to human error. The only method the researcher could identify to reduce the dependency upon human intervention is the use of sensors on Combat and combat service support vehicles. The challenge is to determine how to have combat and combat service support vehicles to automatically send the required data that is sufficient in scope and scale to populate the CPD in CSSCS. Through the use of onboard sensors on combat and combat service support vehicles a method to enable auto-population of the CPD in

CSSCS was identified to provide an initial operating capability (IOC). The remainder of this chapter details the method identified and to answer the two supporting questions of this research.

Utilizing the concepts from *The Process Imperative* and the *Business Integration Journal*, the CPD is divided into manageable and measurable segments for sensor-based population. The four CPD segments analyzed discussed are Fuel, Ammunition, Equipment and Maintenance, and Personnel. Each segment is discussed in detail as to the method and source data required to adequately populate its portion of the CPD starting at the combat platform level through the all the necessary steps to populate the CPD in CSSCS (figure 1).

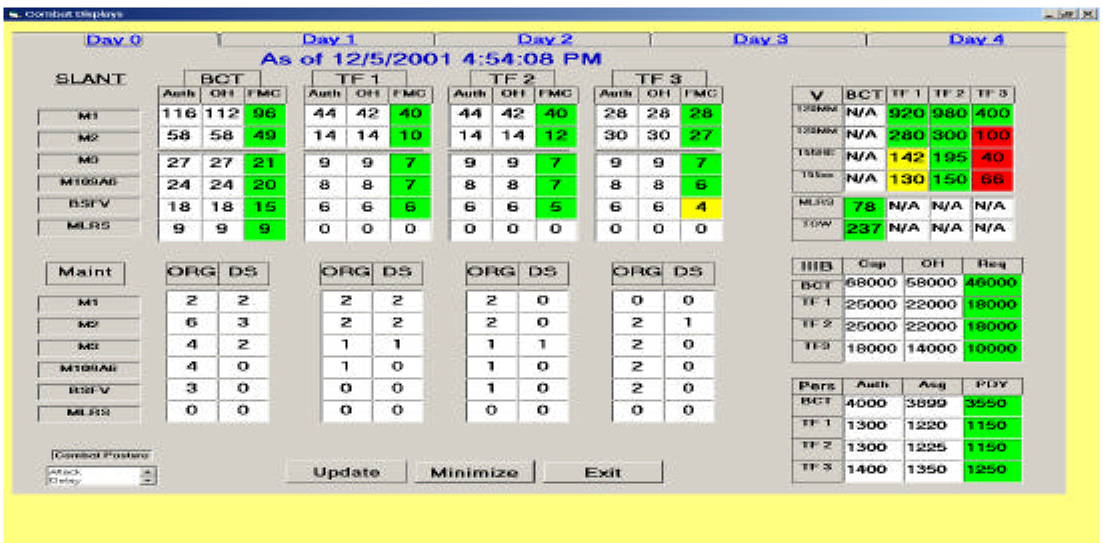

Figure 1. Combat Power Display

Starting at the platform level, the Anticipatory Logistics Concept Experimentation Program provides a “model” for sensor-based feeds from combat and combat service support platforms. The technical approach identified by the Anticipatory Logistics CEP establishes standardization for combat and combat service vehicles. For the purpose of this research, one combat vehicle and one combat service support vehicle is discussed in detail to explain the

concept/technical approach to move sensor-based data feeds to and from these platforms to update the CPD in CSSCS.

To enable sensor-based data feeds to and from combat and combat service support vehicles, each vehicle requires an "Embedded Analog/Digital System" (EAS/EDS) (figure 2) computer that was developed by the Aberdeen Test Center (ATC) to be mounted on each vehicle. The EAS/EAD computer serves as the "brains" of the system and is used for data processing, storage, system interface, and communication links.

Figure 2. The Embedded Analog/Digital System

The EAS/EDS is a rugged, small computer that has a microprocessor, hard drive, PCMCIA data storage capability and external connectors to connect to a vehicle's data bus, computer and communication systems. Without this on-board computer system, no capability exists on combat and combat service support platforms to manage the required interfaces, information management, and data-feeds. The EAS/EDS system is basically an on-board computer that has the capability to interface with a vehicle's on-board sensors, weapons systems, computers, and communications systems.

First, it is important to understand the technical challenges, capabilities, and approach required for combat and combat service support vehicles. Combat and combat service support

platforms vary from being analog or digital-based. In fact, there are some combat and combat service support systems that have both digital and analog capabilities. The M3 Bradley Fighting Vehicle (BFV) serves as an example of a vehicle that as both digital and analog capabilities. The current version of the BFV has a digital- based turret system and an analog-based hull.

Web dictionary defines analog "as of or relating to, or being a device in which data are represented by continuously variable, measurable, physical quantities, such as length, width, voltage, or pressure" and defines digital "as of or relating to a device that can read, write, or store information that is represented in numerical form." To sensor a component on a vehicle that is analog-based, a signal must be sent to a sensor from the EAS/EDS and the return signal from the sensor is received by the EAS/EDS computer and measured. During the research conducted, it was identified that analog vehicles are typically older combat and combat service support systems. The systems have limited capability for sensor-based feeds as a result of the older "analog-based" technology and the actual numbers of sensors onboard on these vehicles are limited. This issue is discussed in greater detail later in this chapter.

Newer and upgraded combat and combat service support systems have the more robust and capable digital- based capability. Systems that have digital capabilities are significantly superior for sensor-based feeds than the older analog system discussed. "Digital systems were developed to maximize the use of on-board sensors" (CASCOM 2001a, 24). Digital-based systems utilize an on-board computer and system databus to send and receives information from sensors. This process of the on-board computer interfacing with the sensors is a constant process. An interesting fact identified during the conduct of this research is that all vehicles sold in the United States are digital-based systems (CASCOM 2001b, 12).

Since, combat and combat service support vehicles have variants that are analog, digital or combined capable, Aberdeen Test Center (ATC) developed a technical approach for each of these cases. Vehicles that are analog-based or that have both analog and digital capabilities must

have an EAS on-board computer to work properly. The EAS version of the on-board computer system has an analog to digital converter built into the system used to interface with the older analog-based combat and combat service support vehicles. Basically, the EAS provides the capability to interface with components of a vehicle that are either analog or digital based. The EAS digital interface was designed by ATC to work seamlessly with the digital capabilities of combined analog and digital-based systems, like the BFV.combat and combat service support vehicles that are purely digital-based systems get the EDS on-board computer. EDS does not have the analog to digital converter built into the system (CASCOM 2001a, 27).

Using the EAS/EDS on-board computer system, the combat and combat service support vehicle concepts are discussed below in detail to explain the concept/technical approach to move sensor-based data feeds to and from these platforms.

Figure 3 depicts a graphical representation of the combat vehicle concept. The combat vehicle depicted in figure 3 is the M3 Bradley fighting vehicle (BFV) with FBCB2 and SINCGARS installed in the weapon system. Since the BFV has both digital and analog capabilities, the system would have an EAS installed in the vehicle. As depicted, the EAS box connects to the BFV's Data Connecter Assembly (DCA). The DCA connector provides the required wiring path to available sensors on board the BFV. This enables the EAS to interface with the sensors on the BFV such as the fuel and maintenance sensors. The engine component in Figure 3 depicts the types of sensors residing on an analog-based BFV. Additionally, the EAS is connected to the "Fire Control" computer and FBCB2. The connection from FBCB2 and the SINCGARS radio provide the communication capability to send sensor-based data off a combat and combat service support vehicle. The connection to the Fire Control computer allows the auto-population of the ammunition portion of the CPD. This process is discussed in greater detail in the ammunition portion of this chapter. Once connected, the sensors on the BFV feed information to the EAS and the EAS auto-populates the LOGSTAT and Call For Support reports residing in

FBCB2. Once populated, the LOGSTAT is forwarded through the normal FBCB2 method discussed in the previous chapter. This process is discussed in greater detail later in this chapter.

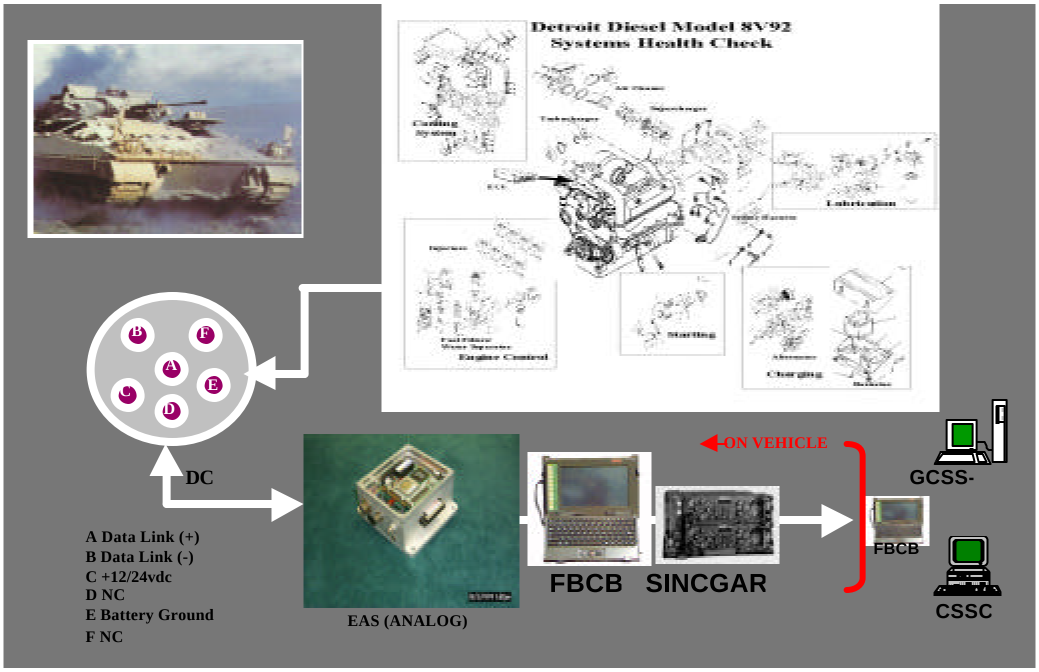

Figure 3. Combat Vehicle Concept

Figure 4 depicts a graphical representation of the combatservice support vehicle concept. The combat service support vehicle depicted in figure 3 is the palletized load system (PLS). Combat service support vehicles can have either movement-tracking system (MTS) as depicted in figure 4 or FBCB2 and SINCGARS to send and receive data. This example uses the MTS system to detail the concept.

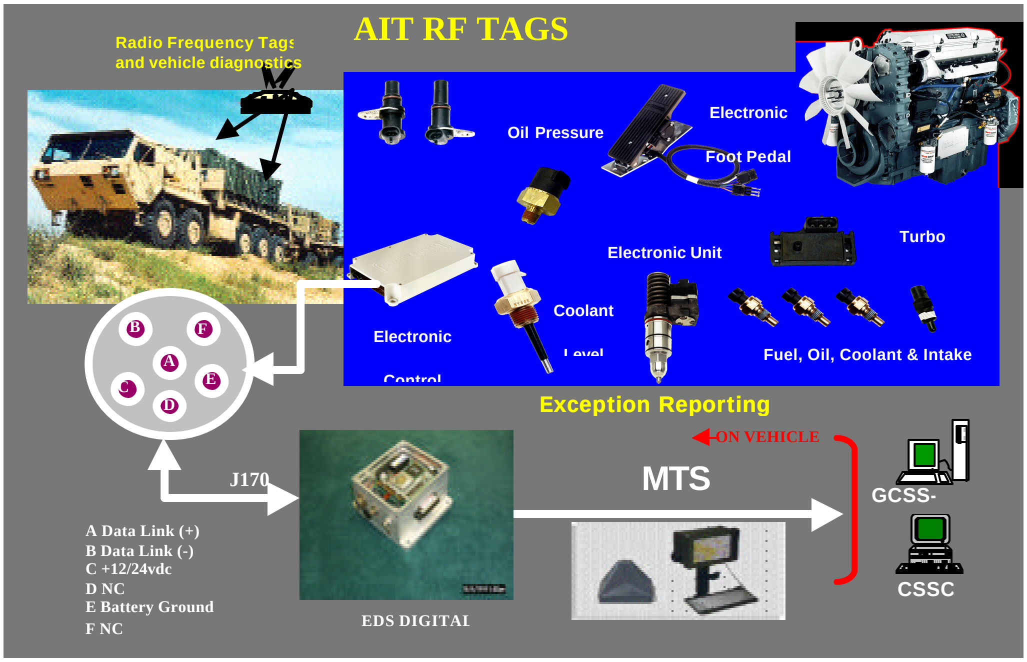

Figure 4. Combat Service Support Vehicle Concept

The PLS is a digital-based vehicle that uses the EAD on-board computer system. To connect the EAD onboard computer the vehicle, the external connector on the EDS must be connected to the PLS's J1708 data bus. This allows the EAD to interface with the suite of sensors organic on the PLS such as fuel and maintenance sensors. Next, the EDS box has the capability to interface with the Radio Frequency (RF) Tags mounted on the supplies the PLS is transporting. This allows the EDS to access the RF tag number assigned to the retail stocks loaded on the PLS. In turn, this would allow the RF tag number to be transmitted to provide asset visibility information. Enabled by the sensor-based data feeds and MTS to transmit near to real time information, the CPD in CSSCS can be updated. Additionally, the visibility provided by MTS including the exact location of the combat service support vehicle with MTS as well asit's organic and retail supplies provide the some of the necessary information to develop a logistics Common Operating Picture.

Both the combat and combat service support vehicle concepts serve as examples for standardization to enable sensors to interface with an on-board computer system. When coupled with a vehicle's communication system, information can be forwarded off the vehicles to provide sensor-based feeds in the Army's logistics and C2 systems. The use of the EAS/EAD system is the primary method to enable the CPD in CSSCS to be auto-populated in the areas Fuel, Ammunition, Equipment and Maintenance, and Personnel.

Figure 5 depicts a graphical representation of the Fuel process concept. The fuel segment of CPD (figure 1) tracks capacity, on-hand, and requirement by Brigade Combat Team (BCT)/Task Forces (TF). These are the areas that need source data that is sufficient in scale and scope to adequately populate the fuel portion of the CPD in CSSCS. The "Capacity" portion of the fuel segment represents the total amount of fuel in gallons a brigade or task force can carry at 100% fill capacity in assigned combat and combat service support vehicles. To get this number, the task organization of the BCT of Task Force is tied to the Standard Property Book System – Redesigned (SPBS-R) for assigned strength levels for the vehicles. Once this number is known then CSSCS multiplies the number systems available by the standardized fuel carrying capability of these refueling assets to populate the capacity portion of the CPD. The sensors from the maintenance portion discussed later can provide maintenance related information as to when refueling vehicles cannot perform their mission due to maintenance related issues.

The "Requirement" portion of the CPD is obtained by the number of gallons of fuel needed to support a BCT or TF. The number of gallons required is determined by a mission profile fuel consumption rate multiplied by the aggregate number of BCT or TF equipment. Fuel consumption rates change when mission profiles change. If a BCT is performing an offense, the amount of fuel required to support this type of operation is significantly higher for fuel consumption than if the BCT or TF is in a defensive posture. This process is an automated process in CSSCS once the correct mission profile is chosen.

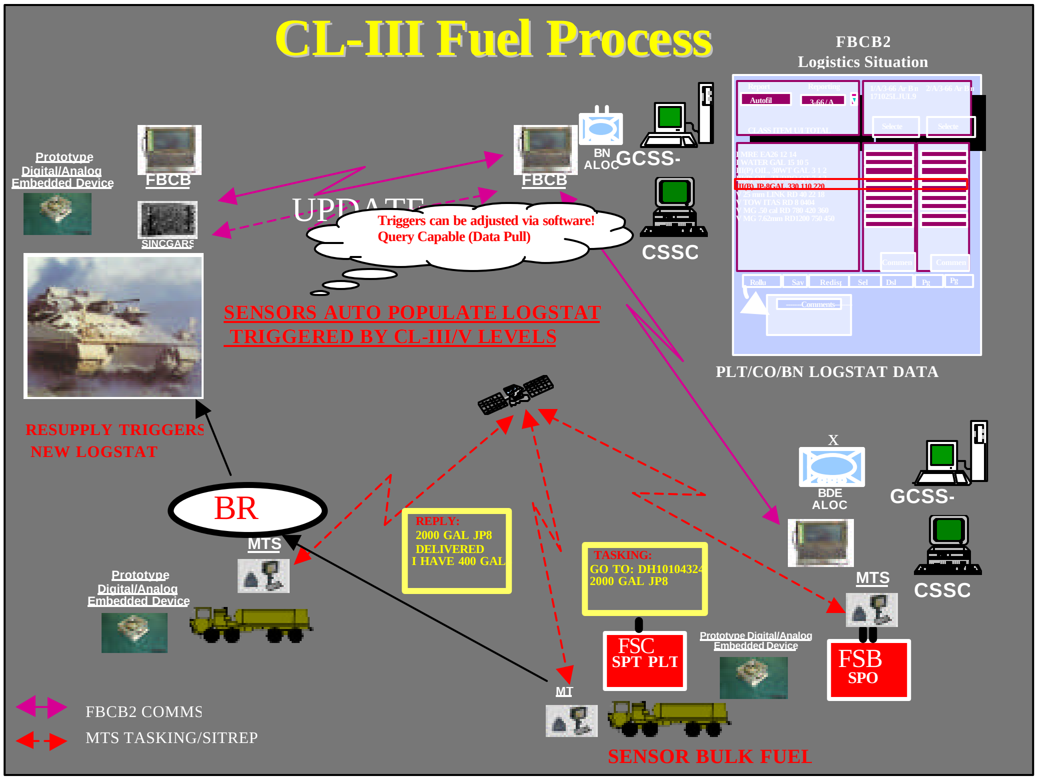

Figure 5. CPD: Fuel Process

The fuel "on-hand" portion of the CPD is obtained by totaling the amount of fuel a brigade currently has on-hand in assigned vehicles. This includes the fuel in brigade combat vehicle tanks as well as the amount of fuel on-hand in combat service support vehicles. M978 2,500-gallon fuel tankers are normally the combat service support vehicles used to perform a brigade's internal fuel resupply missions. Below, the process of populating the fuel portion of the CPD starting at the combat system platform is detailed.

The data required from the BFV is simply the amount of fuel on-board. The EAS residing on the BFV tied to the DCA connecter receives a signal from the sensor located in the BFV's fuel tank. The EAS then takes the fuel level and converts the amount to gallons and logs an entry on

the LOGSTAT report residing in FBCB2. The LOGSTAT in FBCB2 is normally sent twice a day but the reporting frequency can be changed based on each brigade's requirement. Once in the morning at 0600 hrs and once at night at 1800 hrs are examples of LOGSTAT reporting timetable but as stated, the EAS can be programmed to update the LOGSTAT as required. Additionally, if the BFV goes below an established level such as a quarter of tank of fuel, the EDS can trigger an exception report and have FBCB2 to forward the report immediately. This "trigger" can be set to activate an exception report at any percentage level below 100%. This provides the capability to identify specific vehicles that need an "emergency" resupply of fuel.

Once the LOGSTAT is updated, the report follows the normal reporting process of the FBCB2 system. Each LOGSTAT is rolled up at the Platoon and forward via FBCB2 and consolidated at the company level. Once consolidated at the company level, the LOGSTAT is and forwarded via FBCB2 to the battalion S-4. The battalion in turn rolls up the battalion consolidated LOGSTAT and forwards it to the Brigade S4 via FBCB2. The reports discussed are electronically transmitted and the CSSCS database can be update automatically. Once the data resides in CSSCS, the CPD has near real-time information that is accurate and up-to-date. The only time lag identified is the rollup function performed at each level. It is technically possible for FBCB2 to send a message directly to the ALOC for quick information status. Either way, information needs a time date stamp so planners know how old the data is from the platform.

Since the M978 HEMTT 2,500-gallon fuel tanker has an embedded EAS system, the fuel in the tank of the vehicle is known, as well as the fuel in the back of the tanker for retail distribution. In this case, a sensor is placed in the tanker to gauge the amount of fuel available for retail distribution. The EAS system captures this information and sends the data via the MTS system residing on the M978. "MTS provides commanders with near to real time data on the location and status of vehicle movements. "This capability improves effectiveness and efficiency of limited distribution platforms, provide the ability to reroute supplies to higher priority needs,

avoid identified hazards, and inform operators of unit location changes." (MTS ORD, 1998) Once the ALOC receives this information, the ALOC has visibility where the M978 tanker is located on the battlefield and how much fuel is available to perform resupply missions. Additionally, the CPD has the sufficient sensor-based data feeds to populate the fuel segment of the CPD.

The battalion or brigade ALOC can send a tasking via MTS to go to a certain location and issue fuel to company or platoon as required. Once the fuel is received by the combat system located at the resupply point, the crew in the M978 can send a message that mission is complete. The resupply action in turn creates a new LOGSTAT for the BFV and in turn sends the information back up the LOGSTAT process as discussed. Additionally, the ALOC now has visibility of the M978 and its ability to perform future missions due to the reduced fuel on-hand as a result of the previous resupply mission. To refuel a M978 2,500-gallon tanker the use of M969A3 5,000-gallon refueler is normally utilized. The M969A3 can have EAS functionality with the same configuration/concept of the M978 to gain visibility of organic and retail fuel assets; as well as maintenance status of the vehicle. As demonstrated by the Anticipatory Logistics CEP, even a "fuel farm" with bags of fuel on the ground can use the Movement Tracking System linked to a "flow meter" to provide asset visibility and a logistics common operating picture.

In the area of fuel, it is possible to use current C2 systems and sensors to provide a near-perfect logistics combat power estimate to Army brigade commanders. As discussed, all the data requirements to populate the CPD in CSSCS can be sent via sensors mounted on combat and combat service support platforms. The capabilities of the MTS system coupled with sensors providing the amount of fuel in a vehicle for organic use as well as retail supply provides the ALOC with timely, accurate and up-to-date data. Enabled by the timely and accurate sensor-based data feeds, the ALOC can use the proposed solution to improve C2 and decision-making capability in the area of fuel. A logistics Common Operating Picture can be achieved through the

integration of FBCB2 and MTS data. As demonstrated by the Anticipatory Logistic CEP, the ALOC had visibility of the tactical situation as well as the current combat Service Support supplies on-hand and vehicle locations. Due to the increased accuracy and visibility provided by this data, the ALOC can use this information to better plan and conduct a combat service support current and future resupply operations. The capability achieved through the integration of the various technologies enabled sensor-based data feeds to answer the secondary question posed in this thesis: How can the ALOC use the proposed solution to improve C2 and decision making? Specific improvements in ALOC C2 and decision-making are discussed in greater detail at the end of this chapter but the most significant impact achieved is the ability to better build, maintain and sustain a brigade's combat power through improved asset visibility gained through sensor-based data feeds.

Another significant achievement is that the capabilities discussed can be achieved with little to no human intervention, thereby significantly improving the accuracy and timely updates of the CPD in CSSCS. As discussed, sufficient capability exists to use sensors and the current C2 systems to update the fuel segment of the CPD in CSSCS.

Figure 6 depicts a graphical representation of the Ammunition process. The ammunition segment of the CPD (Figure 1) depicts the total number of specific rounds that are tracked by a brigade. The total numbers of rounds available is the aggregate of a brigade's Unit Basic Loads (UBLs). The Class V (ammunition) types of rounds tracked on the CPD are tailorable and can be changed to different types of rounds if a commander determines the need. Additionally, the ammunition segment of the CPD lists the Brigade Combat Team (BCT) and the associated number of subordinate Task Forces (TF) that are created to support an operation. An example is Figure 1 of the CPD lists TF 1 with 920, 120mm rounds on-hand. Color coding of the round count is based the red, green, yellow or black concept. Based on the requirement, the number rounds on-hand is divided by the number of rounds needed to accomplish a mission. The number

of rounds needed to accomplish a mission is obtained by the appropriate ammunition planning factor for a specific mission profile in CSSCS. Listed below is the process of updating the ammunition segment of the CPD in CSSCS from sensor-based data feeds from a combat vehicle.

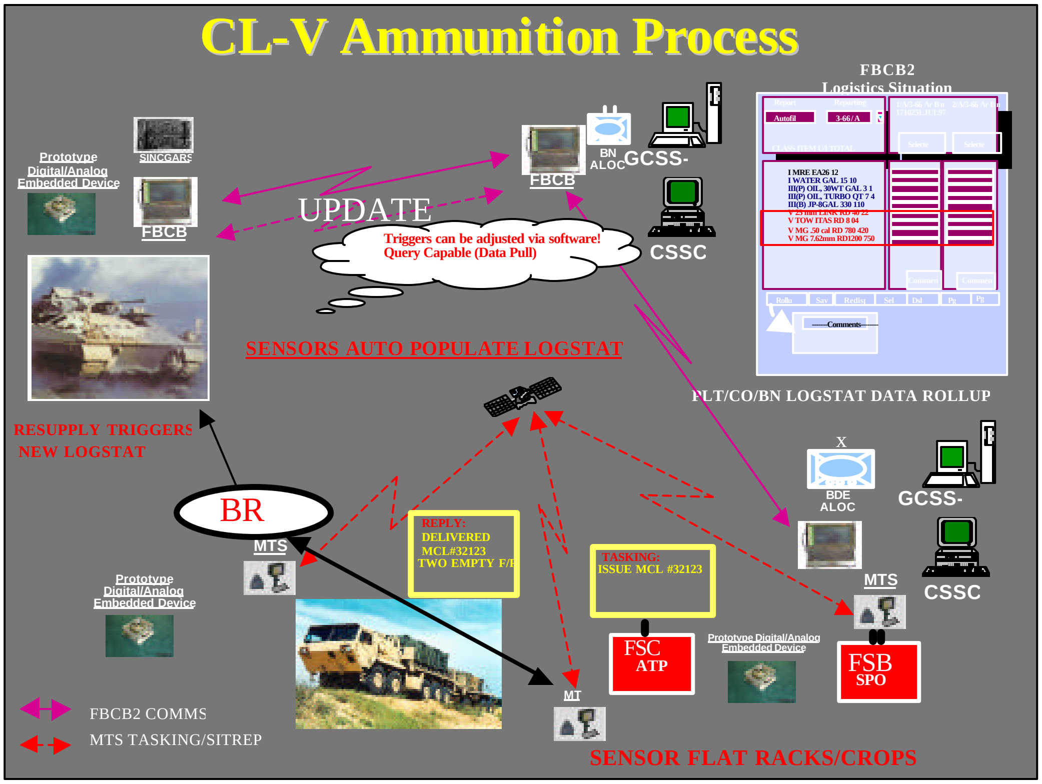

Figure 6. CPD: Ammunition Process

The EAS residing on the BFV is connected to and interfaces with the Fire Control computer on-board the BFV. When ammunition is loaded into the BFV, the Fire Control computer captures the number of rounds and stores this information in its database. As the weapon system is fired, the fire control computer decreases the amount of rounds commensurate to the number fired. The EAS in turn, captures the roundcount as it is decremented during firing of the main gun. Additionally, if the ammunition level on the BFV goes below an established

level, the EDS can trigger an exception report and have FBCB2 to forward the report immediately. This “trigger” can be set to activate an exception report at any percentage level below 100%. The use of “rack mount” based sensors can count the number of rounds placed in the storage bin of the weapon system. The EAS once wired into the storage bin sensors will have visibility of ammunition on the BFV. Once the EAS and FBCB2 are interfacing, the LOGSTAT is updated with the total number of rounds in the vehicle. As stated earlier, the method used currently to gain visibility of weapon system ammunition is manual. If required, soldiers can manually update the LOGSTAT if “non-standard” storage is utilized to carry ammunition on the vehicle. The EAS logs an entry on the LOGSTAT report residing in FBCB2 and the LOGSTAT is consolidated and forwarded by FBCB2.

The battalion or brigade ALOC can send a tasking via MTS for an internal resupply mission as required. Once the ammunition is received by the combat system and the resupply operation is complete, the crew in the PLS sends a message that mission is complete to the ALOC. This provides the visibility to the ALOC that the PLS is available for re-tasking. Once the BFV is loaded, the EAS updates the LOGSTAT and FBCB2 forwards the report accordingly. For retail resupply at an Ammunition Transfer Point (ATP), data flow and sensor based-feeds are basically the same as Brigade internal resupply missions. The ALOC C2 and decision-making capabilities are improved in ammunition as discussed in the fuel process. The Anticipatory Logistics CEP demonstrated that it is possible to use sensors on combat and combat service support platforms to feed the current C2 systems. These feeds can update the CPD in CSSCS and significantly improve the accuracy of information residing in CSSCS. The accuracy of projected ammunition requirements accessed by the “Forecast Tabs” of the CPD is dependent upon the accuracy of the forecasting planning factors used in CSSCS. Sensors can help to refine the planning factors by providing actual numbers of rounds that were expended during an operation.

This information can be used to refine the ammunition planning factors to increase the accuracy of future ammunition forecasting requirements.

Figure 7 depicts a graphical representation of the Slant and Maintenance Processes. As depicted in the CPD (figure 1), the slant and maintenance segments of the CPD list the type of weapon system by Brigade Combat Team (BCT) and/or the associated number of subordinate Task Forces. The systems that are tracked on the CPD are driven by the Commander's Critical Tracked Item List (CCITL) resident in CSSCS. What is tracked is tailorable and can be changed based on mission requirements. The authorized number of tracked weapon systems is driven by the task organization of the BCT of Task Force tied to the Standard Property Book System – Redesigned (SPBS-R). Once utilized, the EAS can update the LOGSTAT with system specific information such as end item type and unit assigned. This is important due to the fact that items that cannot be repaired sometimes are replaced by another vehicle from the Direct Support maintenance company with an asset called an Operational Readiness Float (ORF). ORF is a limited number of systems available to "swap" with the customer to increase the combat power of the brigade by providing a Fully Mission Capable (FMC) system while the customer's system is receiving time-consuming repairs. The problem is that these ORF assets are not on the property book of that brigade and CSSCS would not have asset visibility to update its database. The information provided by the EAS would solve this problem.

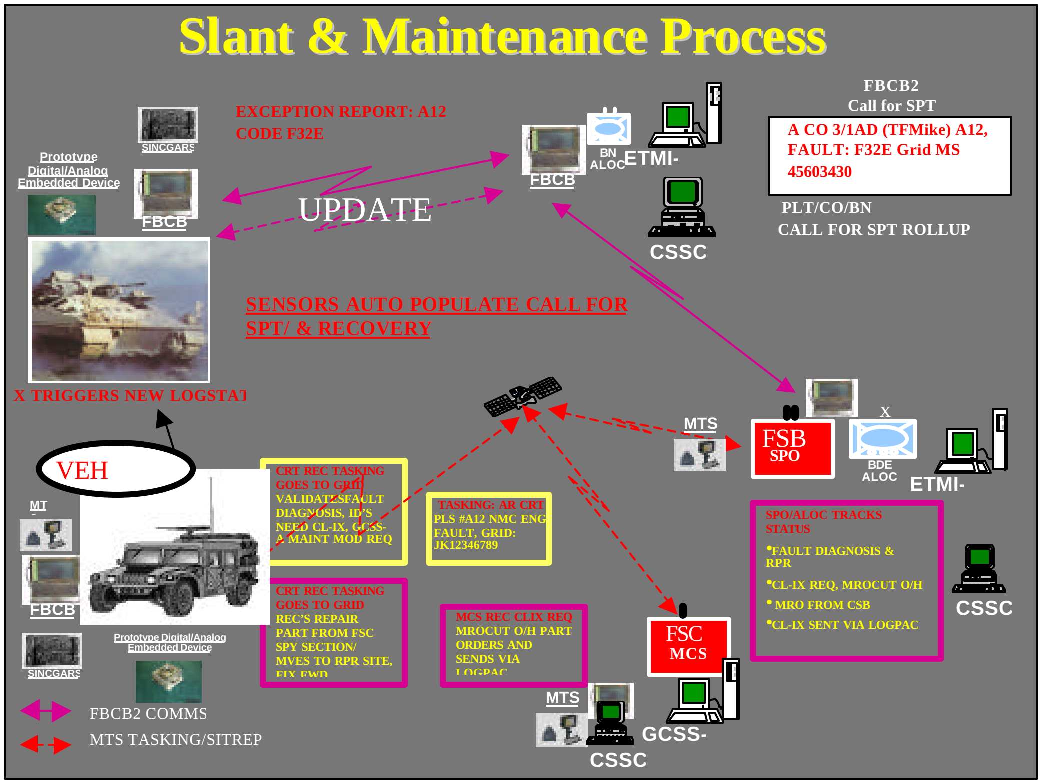

Figure 7. CPD: Slant and Maintenance Processes

The On-Hand amount column is the number of systems physically possessed by the BCT or TF. It is obtained by from a feed of the SPBS-R system. There are four reasons why a brigade will not be at the Authorized level listed on the CPD: the weapon system was not issued, in Org or direct support maintenance or the weapon system was destroyed in battle. The Fully Mission Capable (FMC) segment is the number of weapon systems available that are capable of conducting their missions. The numbers for the maintenance section of the CPD list the number of systems in organizational and direct support. Listed below is the equipment and maintenance process starting at the platform level.

The EAS residing on the BFV is connected to the DCS connector and interfaces with the sensors on board the BFV, such as the cooling, starting, charging, and engine control. The EAS demonstrated during the Anticipatory Logistics CEP demonstrated diagnostic and prognostic failures. For the diagnostic failure, an alternator that failed was demonstrated. The EAS computer generated a failure code that auto-populated the “Call for Support” function in FBCB2. The Call for Support function in FBCB2 is currently a function that requires a system’s crew to manually fill out an electronic request for maintenance support. With the EAS, this report was auto populated and forwarded off the platform. The prognostic capability of the EAS was to demonstrate a component that would fail in the future through the use of linear regression analysis.

To predict a failure for a component, the EAS/EDS on the BFV in the Anticipatory Logistics CEP sent a test signal to an alternator. In turn, the alternator sent a signal back to the EAS/EDS onboard computer. The platform specific software loaded on the EAS/EDS had component parameters stored in its memory. Using Linear Regression Analysis as depicted in figure 8, the EAS/EDS compared the test result to these stored parameters. As time/mileage progresses and a component or in this case the alternator starts to fail, the signal from the alternator will fall into the yellow band. The software on the EAS/EDS predicts the failure point and provides the number of hours/miles remaining before the component fails. A specific failure code from DA PAM 738-750 Table B (August 1994) is posted on the “Call for Support” report in FBCB2. If the vehicle is a combat service support vehicle then “MTS will interface with embedded equipment diagnostic and prognostic systems will provide accurate data that will aid fleet maintenance” (CASCOM 1998). This process is designed using the same concept as the OnStar system. If a warning light in the vehicle is activated, the vehicle can transmit any problem codes generated by the vehicle engine computer. The problem codes are generated from the onboard computer directly linked to sensors mounted on a vehicle.

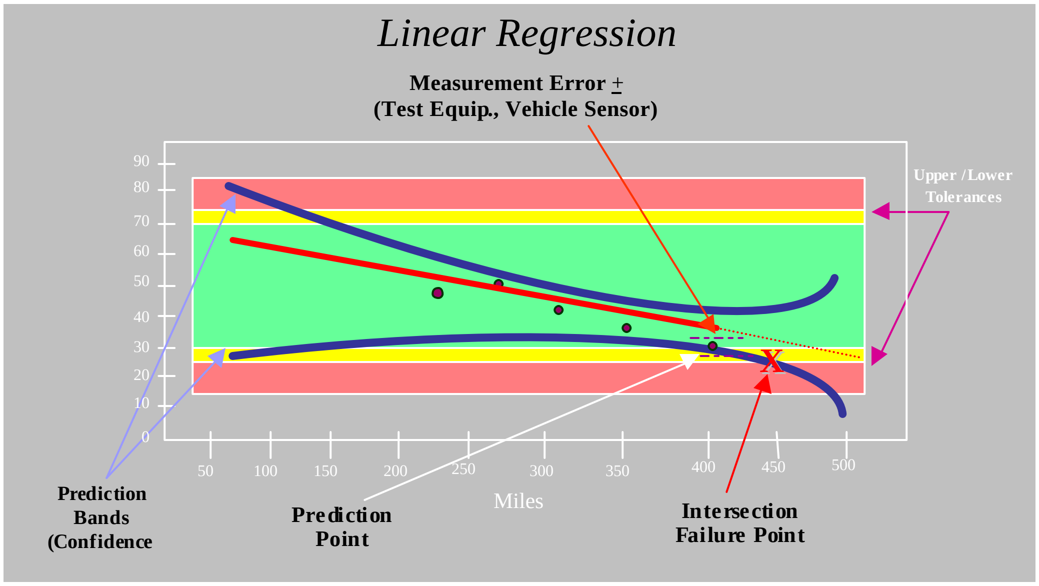

Figure 8. Predictive Maintenance

The Call for Support is forwarded via FBCB2 and interfaces with the Unit Level Logistics System Ground (ULLS-G). Using the electronic technical manual interface (ETMI) software developed by the Logistics Integration Agency (LIA), the part can be ordered automatically ordered by the ULLS-G computer. At end state, the capability exists for an organizational level component to fail or as result of prognostics, projected to fail and a requisition established for the component without human intervention. If the repair of the vehicle requires direct support level maintenance, a Maintenance Support Team (MST) with MTS on board the support vehicle can be dispatched to perform a Direct Support repair. As with any system utilizing MTS, C2 of the MST is significantly increased by this system.

Once the system is repaired, an update is forwarded via the ULLS-G computer to SAMS 1 and 2 then to CSSCS where the information on the CPD is updated.

Unfortunately, the problem is that the software for the EAS/EDS is not mature to enable robust diagnostic and prognostic capabilities. Additionally, the number of components that have sensors on analog combat and combat service support equipment is limited and do not cover all critical systems on-board the vehicle. As a result of both issues discussed, detailed diagnostics and prognostics are not currently sufficient in scale and scope to adequately populate the CPD in CSSCS. Therefore, the CPD in CSSCS is dependent upon feeds from the ULLS-G, SAMS 1 and SAMS 2 data feeds, as well as the sensor-based data feeds that are available. As stated, digital systems have significantly better diagnostic capabilities and more components that have sensors. To establish standardization, each combat and combat service support platform must be assessed as to the capabilities and limitations of on-board sensor capabilities.

The Personnel segment of the CPD in CSSCS lists the authorized number of personnel by Brigade Combat Team (BCT) and/or the associated number of subordinate Task Forces. The assigned (Asg) number is the actual number of personnel assigned and present for duty (PDY) number is the number of personnel physically present and capable of performing their assigned missions. A soldier who is injured and is a hospital would be an example of a soldier not PDY. An extensive search for sensors that could update the CPD in combat service support for personnel was conducted but no promising work was located. As a result, the CPD is dependent upon the information residing in CSSCS for its level of accuracy.

The primary research question of this thesis is: Using current C2 systems, is it possible to use sensors to provide a near-perfect logistics combat power estimate to Army brigade commanders? The analysis of the research materials and methodologies discussed in the previous chapters provide a potential solution to the problems discussed. An Initial Operating Capability (IOC) can be established because a solution is technically available but as discussed, much work is needed to mature the technology.

The next issue addressed is if implemented in CSSCS, can the CPD provide the required logistics combat power visibility to Army brigade commanders to plan and conduct missions at the brigade level? FM 3-0 (100-5) states that: “Combat Power is the ability to fight. It is the total means of destructive or disruptive force or both, that a military unit or formation can apply against the opponent at a given time. Future combat power is “the projection of combat power given a battle rhythm and phase of an operation, overtime by unit” (CAC 2002, 18). The answer to this question is centered on the sufficiency of information provided by the CPD that is used by commander for decision-making. The best possible source identified by the researcher to answer this question was obtained by querying current and former commanders. This was the exact approach used by Combined Arms Center to develop the CPD. To that effort, the Combined Arms Center commander requested input from tactical commanders to specifying what logistics information they required to view their combat power and if CSSCS was sufficient in providing this information. Combined Arms Center received information from V CORPS, 18th ABC, 82nd, 1st ID, 1st CD, 24ID, BCTP, NTC, and CTSF, and TRAC. The overwhelming response received was that CSSCS is too hard to use and basically, not “user-friendly.” Additionally, the following responses were received by Combined Arms Center:

- Responses mirrored each of the unit’s Battle Update Brief information formats.
- Develop an interface display that can reside on any ATCCs or light client (windows based system) that provides the commander on-call/instant combat power information.
- Provide and interface similar to the CDR’s BUB format with ease of use.
- Tailorable to their BOS.
- Updated with a single click
- Provides information with a DTG.

To solve the issues identified by these commanders, Combined Arms Center used the slant reports used by these units to depict combat power/status and BOS information and consolidated the information into the CPD. The initial version of the CPD was sent back to the commanders for review. Combined Arms Center asked the commanders to provide recommended

changes to the CPD to ensure all logistics information required for effective C2 and decision-making resided on the series of charts. After the recommended changes were made to the CPD,it was accepted by the commanders as sufficient in scale and scope with the required logistics information to depict their unit's combat power. Additionally, the graphic user interface (GUI) used to design the CPD effectively consolidated a brigade's combat power estimate in "user-friendly" views by providing information in a format tailored to their BOS and operational status.

In summary, feedback received stated that commander's CPD formats the required critical information in an easy to use format that "Allows Commanders and Staff to have immediate access to combat power information related to combat service support (On-Call Status in garrison or tactical operations)" (CAC 2002, 17).

The final question addressed in this thesis is how can the ALOC use the proposed solution to improve C2 and decision making? Throughout this chapter numerous examples were given that confirmed C2 and decision-making could be improved in the ALOC. The key to improving C2 and decision-making in the ALOC is the integration of the numerous technologies discussed to achieve an improved Logistics Common Operating Picture. Like the civilian system OnStar, the solution detailed can provide unparalleled visibility of the battlefield. The ALOC requires the ability to see the enemy and friendly units including critical combat and combat service support equipment and personnel. Unfortunately, FBCB2 and CSSCS do not adequately provide this capability. Combat service support retail assets on combat service support vehicles are not reported via FBCB2 and CSSCS and overlays depicting the locations of combat service support supply points are manually input into these systems. Since the retail assets on the combat service support vehicles are not reported the ALOC has no real-time information for asset visibility. Additionally, supply point icons remain static until manually changed. As a result, The ALOC has limited visibility to plan and conduct combat service support missions that would build, maintain, and sustain combat power for the brigade

To increase the C2 and decision-making capability of an ALOC, the ALOC needs a logistics common operating picture that presents accurate visibility of current and projected combat ready personnel, equipment and supplies. The concept developed and tested during the Anticipatory Logistics CEP took source data obtained from sensors on combat and combat service support vehicles and forwarded the data via FBCB2 and MTS. Also, a Class III retail bulk fuel supply point was also fitted with sensors and MTS. All data feeds from the vehicles and the supply point were sent to an ALOC “mock” computer system designed to mimic CSSCS. The C2 system in the ALOC had “real time” data feeds that populated a combat service support overlay resident in the system. Due to the real-time feeds in the C2 system in the ALOC, the ALOC had “real-time” visibility of the class III bulk supply point and the combat and combat service support vehicles. The combat service support overlay in the mock CSSCS system depicted “real-time” vehicle movements and combat service support status for fuel, ammunition and maintenance status.

Additionally, the capabilities of FBCB2 which include the locations of friendly and enemy forces were integrated with the Logistics based data-feeds from combat and combat service support vehicles. Through this integration of the technologies, the ALOC had an Initial Operating Capability for a Logistics Common Operating Picture. Enabled by the Logistics Common Operating Picture, the ALOC had the ability to see friendly forces, enemy forces, and real-time combat service support supply point locations and vehicles. This information provided by the Logistics Common Operating Picture provided the ALOC with visibility of more accurate supply requirements and the ability to dynamically route and reroute combat service support assets to conduct combat service support resupply operations.

The research conducted to date has performed a “proof of concept” that is technically possible to achieve an Initial Operating Capability for a Logistics Common Operating Picture. Enabled by this capability, the ALOC C2 and decision-making capability is improved.

This chapter has provided the analysis of potential solutions to methods to determine if it is possible to use current C2 systems and sensors to provide a near-perfect logistics combat power estimate to Army brigade commanders. Additionally, this chapter provided a detailed analysis of the two supporting questions: Is the current CPD adequate to provide the required logistics combat power estimate to Army brigade commanders to effectively plan and conduct missions at the tactical level and how can the ALOC use the proposed solution to improve C2 and decision making in the ALOC.

The final chapter will use the research and analysis conducted and builds upon this work to make recommendations to improve the method to provide a commander with a near-perfect logistics combat power estimate.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

> Our imagination is the only limit to what we can hope to have in the future. (1927, 2)
>
> Charles F. Kettering

At the brigade level, one of the most critically important information requirements needed by a brigade commander to plan and conduct military operations is the visibility of his unit's combat power. CSSCS is the primary C2 system designed to provide a commander with a logistics combat power estimate. Unfortunately, CSSCS is subject to data-feeds from various systems that are dependent upon manual entry. This causes CSSCS data residing in the system to be subject to human error and updates that are submitted either late or in the worst case, never input. To that effort, the main purpose of this thesis was to determine if there is a better method to populate and update the current C2 systems through the use of sensors to provide a near-perfect combat power estimate.

Research Questions

The primary research question of this thesis is: Using current C2 systems, is it possible to use sensors to provide a near-perfect logistics combat power estimate to Army brigade commanders? Additionally, this research seeks to answer the two supporting questions posed in this thesis: Is the current CPD adequate to provide the required logistics combat power estimate to Army brigade commanders to effectively plan and conduct missions at the tactical level and how can the ALOC use the proposed solution to improve C2 and decision making in the ALOC?

Conclusions

Based on the research and analysis conducted, it is technically possible to use current C2 systems and sensors to provide a logistics combat power estimate to Army brigade commanders but the scale and scope of the information that is “sensor-based” is limited. Due to the limited number of available sensors currently residing on combat and combat service support analog-based vehicles, not all vehicles can provide the required information in sufficient detail to populate all sections of the CPD in CSSCS. It is important to note that sufficient information resides in CSSCS to populate the CPD. The issue is what data is available from sensors on combat and combat service support vehicles that enables the CPD in CSSCS to be auto-populated in the areas Fuel, Ammunition, Equipment and Maintenance, and Personnel.

An Initial Operating Capability for a sensor-based logistics combat power estimate can be established for fuel, ammunition, equipment, and maintenance. Unfortunately, no sensor technology was identified to populate the personnel portion of the CPD. In the areas of fuel and ammunition, enough sensors are available on combat and combat service support vehicles tested during the Anticipatory Logistics Concept Experimentation Program but not all weapon systems were tested or evaluated. As a result, each critical combat and combat service support vehicle must be evaluated to determine the sensors availability. Obviously, the more sensors that are available on these systems the less the CPD is dependent upon non sensor-based data.

The maintenance portion of the logistics combat power estimate is an example of the problem caused by the limited number of sensors on critical components. Numerous critical components that could render the vehicle inoperative currently do not have sensors that the EAS/EDS onboard computer could be connected. The next issue is that the EAS/EDS onboard computer created by the Aberdeen Test Center has significant capabilities but the software is currently not mature enough for robust diagnostic and prognostic capabilities for the maintenance portion of the CPD residing in CSSCS. Additionally, no sensors was identified to auto populate

the personnel section of the CPD resulting in this segment's accuracy being totally reliant upon the current information residing in CSSCS. The other functions the EAS/EDS perform such as system and communication interface capabilities are mature enough to perform its intended mission of information management on-board combat and combat service support vehicles. In summary, the concept was demonstrated successfully but significant work must be accomplished to mature the EDS/EAS method to populate the CPD in CSSCS using sensor-based feeds from combat and combat service support vehicles.

To answer the questions if the current CPD developed by Lieutenant Colonel John P. Curran of the Combined Arms Center is adequate to provide the required logistics combat power estimate to Army brigade commanders, the CPD was reviewed and refined by tactical commanders. After a few changes were made based on the input from these commanders, the CPD was deemed sufficient in the scale and scope of logistics information required to effectively plan and conduct missions at the tactical level. Additionally, the CPD displays the required logistics information in an easy to use format for use by a commander and staff.

The last research question, how can the ALOC use the proposed solution to improve C2 and decision making in the ALOC? The integration of the technologies discussed improves the ALOC's C2 and decision-making capability through achieving a Logistics Common Operating Picture. The Logistics Common Operating Picture enables the ALOC to have significantly improved situational awareness by enabling the ALOC to see friendly forces, enemy forces, and real-time combat service support supply point locations and vehicles. The degree of situational visibility achieved is unparalleled. Additionally, the ALOC has visibility of more accurate supply requirements for the brigade as well as the ability to dynamically route and reroute combat service support assets to conduct combat service supportresupply operations. This is a significant achievement due to the fact that no current capability existedprior to this research that could provide this level of situational awareness at the brigade level.

Recommendations

It is recommended that the research and analysis of this thesis be used as a baseline to develop an Initial Operating Capability to populate and update the current C2 systems through the use of sensors to provide a near-perfect combat power estimate. Additionally, use the proposed solution as a baseline to improve C2 and decision making in the ALOC.

One assumption made by the researcher was that CPD functionality had been developed in CSSCS. The research conducted clearly shows a need for CPD functionality in CSSCS. CSSCS is the only system designed and fielded to perform the function of logistics C2. Therefore, it is essential that functionality is increased to ensure commanders and staff use the system. It is recommended that a Software Change Package (ECP) be developed to immediately integrate CPD functionality in CSSCS. As stated, all the data necessary to populate the CPD resides in CSSCS and this would enable commanders to view their combat power in "user-friendly" view; a capability currently not available in CSSCS.

The civilian industry has significant work accomplished that contributes to achieving more robust sensor-based capabilities. It is not feasible to put a sensor on every component of combat and combat service support vehicles. The approach recommended is to use or install sensors on combat and combat service support vehicles for the "system-critical" components of each system. Only sense components that would provide asset visibility or that would render the system non-mission capable if these components were to fail. There are numerous civilian companies that have developed additional sensors to increase the sensor coverage for critical items on a vehicle. An example is the "Honeywell Sensing and Control" company. They provide solutions for a wide variety of system-critical vehicle applications, such as engine management, transmission control, wheel-speed, and motor control. As these systems are modernized and

upgraded, additional sensors can be installed and the combat and combat service support system can be converted to digital based.

When the Army purchases new weapon systems, it is strongly recommended that standardized requirements be established in all combat and combatservice support vehicle procurement contracts. Ensure these systems are digital-based with robust diagnostic and prognostics capabilities and sufficient sensors are resident on these systems to provide the information discussed.

Additional work needs to be performed to identify sensors to feed the required source data for the personnel section of the CPD to increase the data accuracy of this segment. Last, an integrated approach needs to be taken to further develop this concept. Due to the nature and complexity of this issue, a battle lab or other agency needs to be assigned this project by TRADOC to fully integrate and develop this capability.

Summary

As new technology has emerged, many solutions to the problems discussed in this thesis are achieved. By capitalizing on these emerging technologies, new and innovative methods to "fight and win" our nation's wars can be obtained. Meeting the challenges inherent in "full spectrum" operations has presented Army commanders with missions that without question are becoming more and more complex. As a result, the need for timely and accurate information is becoming even more critical to enable commanders and staff to effectively plan and conduct operations at the tactical level. Commanders and staff do not have the luxury of large amounts of time to plan and conduct these operations. Information needs to be accurate, up-to-date and sufficient in scale and scope. Additionally, information needs to be presented in a "user-friendly" method to expedite and improve the C2 and decision making on the battlefield. The method discussed in this thesis is just one way to provide the situational awareness required to build, maintain and sustain combat power to enable a unit to fight and win. Regardless of the method

chosen, it is important that a capability is established to better enable a comman9der and staff to plan and conduct military operations through the full spectrum of military operations.

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